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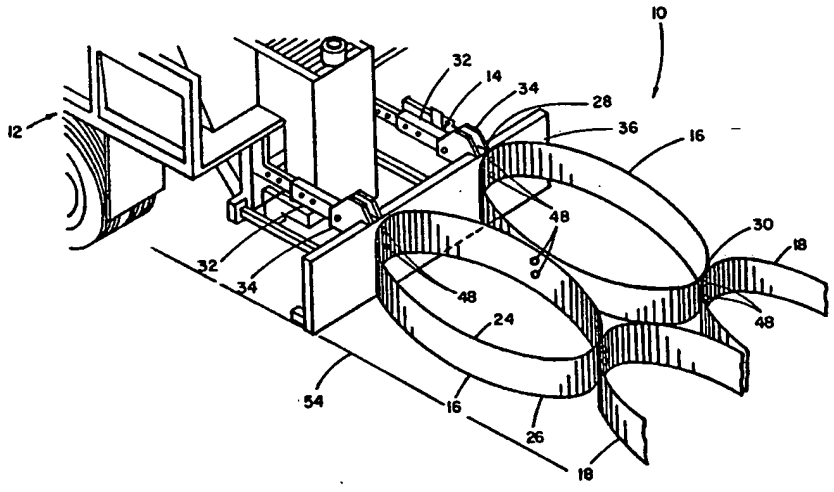


(57) Abstract

An impact attenuation system which uses vertically standing, hollow, cylindrical energy dissipators (16, 18) having elliptical shaped cross sections. The cylindrical energy dissipators (16, 18) can be used in connection with prior art impact attenuation systems which used round cylinders. In one application, the protected structure is a truck (12) and the system is attached to the truck (12) by a series of brackets (32). A brace (34) is pivotally attached to the bracket (32) and a plate (36) is attached to the brace (34). One or more elliptical cylinders (16, 18) are attached to the plate such that the minor diameters of the elliptical cylinders run substantially parallel to the plate and the major diameters of the elliptical cylinders (16, 18) run substantially perpendicular to the plate. A radial slit (50) is cut out of the rear most cylinders (18) proximate to the top and the bottom. The slits (50) are arcuate and extend substantially about the back half of the rear-most cylinder (18).

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# DESCRIPTION

## "IMPACT ATTENUATION DEVICE"

### TECHNICAL FIELD

The present invention relates generally to an impact attenuation device and more particularly to an energy absorbing system employable for reducing the severity of vehicular collisions, especially the type involving a fast moving motor vehicle and a work piece such as a road barrier or a highway service vehicle used in highway maintenance repair operations, from the standpoint of limiting the extent of injuries suffered by people and the damage done by the equipment as a consequence of such collisions.

### BACKGROUND ART

It will be appreciated by those skilled in the art that public highway and safety departments have employed a variety accident preventive measures in an effort to prevent and/or reduce the personal injuries and property damages resulting from vehicular collisions occurring on the nations's major highways as well as its local roads. Such accident preventive measures may be classifiable for purposes of this discussion into two basic categories: warning devices designed to be operative to forestall the occurrence of a vehicular collision and protective devices designed to afford protection to both persons and property in the event of a vehicular collision.

By way of illustration, the category of warning devices includes such items as conventional traffic signs and traffic signals, emergency signs and signals displayed to warn of the temporary existence of a dangerous situation, etc.

Protective devices fall into two classes, i.e., those embodied in a vehicle as part of the construction thereof, and those which are viewed as being separate from the construction of the vehicle regardless of whether the latter are subsequently affixed in some manner to the exterior of the vehicle. Examples of protective devices which fall within the first class, are such things as padded dashboards,

seat belts, etc. In the second class, are such things as various types of safety barriers designed to afford protection in the event of a vehicular collision between a moving vehicle and a stationary object or between a moving vehicle and another moving object.

The present invention relates to a protective device of the type falling within the second class of items discussed hereinabove. The features include protection against immoveable objects such as bridge peers, light stations, guard rails, sign posts, concrete walls, abutments, and the like. Typically, an attempt is made to afford protection against a moving vehicle striking such immovable objects by positioning stationary traffic safety barriers in proximity to the immovable object and arranged so that they lie along the path which the moving vehicle would most likely follow if it were to strike the immovable object. Such stationary traffic safety barriers are most often intended to function as an impact attenuation device; namely, to attenuate the impact produced as a result of the collision between the moving vehicle and the immovable object. Dissipating kinetic energy in a controlled manner will help to reduce the severity of the vehicular collision as defined by the extent of injury suffered by individuals riding in the moving vehicle and the amount of property damage incurred by both the moving vehicle and the immovable object.

For ease of reference during the following discussion, such stationary traffic safety barriers will be referred to as impact attenuation devices. One of the earliest attempts made at providing an impact attenuation system involved the employment of systems composed of 55-gallon drums. Patterns were cut into lids of the drums to reduce the crushing strength of the system, i.e., to provide the system with the desired controlled crushing characteristics. The successful implementation of this 55-gallon drum modular crash cushion system prompted a study of the feasibility of employing other possible forms of stationary energy absorbing barriers. In

this regard, corrugated steel pipe was found to have favorable characteristics when it was statically crushed tested. Moreover, the availability of corrugated steel pipe having a wide range of thickness and diameter dimensions made it feasible to employ a poly-modular design to which the physical characteristics of the stationary energy absorbing barrier could be varied on a row to row basis.

Examples of other forms of impact attenuation systems which are known to exist in the prior art include the following: a hydrocushion cell barrier composed of an array of water filled plastic cells operable such that upon impact, the water is ejected through orifices in the top of the cells at a controlled rate; a barrier formed by an array of nine to seventeen sand filled frangible plastic barrels, which is characterized by its versatile applicability; a U-shaped tubular guard rail energy absorbing barrier that absorbs energy by means of the motion of supporting telescopic tubes such that upon impact, the impact forces are transmitted axially to arms, which contain many stainless steel torus elements that are squeezed between two cylindrical tubes; a barrier in the form of a vehicle arresting system that is composed of a steel entrapping net positioned across a roadway, and which is particularly applicable for use in proximity to locations such as road dead ends, ferry landings, highway medians, and bridge overpasses, etc.; a light weight cellular concrete crash cushion barrier constructed of easily frangible vermiculite concrete with vertical voids wherein the vertical voids contribute to the controlled crushing characteristics of the barrier; for use primarily as part of a guard rail system, a barrier used on a fragmenting tube concept, which was originally developed for use in planned lunar landing modules, and in which energy is absorbed by forcing a thick-walled aluminum tube over a flared die, resulting in the shedding of the tube into small segments; and lastly, an energy absorbing barrier particularly applicable for use as part of a guard rail

system in which thick walled steel rings are utilized.

In addition to the potential for danger imposed by immovable objects, which are to be found located along the nation's major highway and along its local roads, there is another situation, which has a potential for danger that one often encounters while traveling along these same major highways and local roads. References is had here to the hazardous condition often imposed by the presence on such highways and roads of men and equipment engaged in highway maintenance and repair operations. There is a need to protect such personnel and equipment from being struck by an errant moving vehicle. The impact attenuation systems which have been described herein previously are generally found to be unsuited to provide the desired degree of protection to the personnel and equipment while involved in conducting highway and road maintenance operations. To provide this needed protection, what is needed is an energy absorbing barrier which is portable in nature in contrast to the stationary nature of the energy absorbing barriers to which reference has been had herein.

Although most of the attention in the prior art has been directed toward providing various kinds of stationary energy absorbing barriers, there is known to exist in the prior art at least two different types of impact attenuation systems, the latter more commonly being viewed as comprising a system. One such portable energy absorbing system is in the form of a hydro-cell system that consists of five rows of thirteen polyvinyl chloride plastic cells enveloped in a corset-like membrane. The entire unit is mounted on a metal platform, which is designed to be attached to the rear of a highway service vehicle. Each cell contains approximately 3 1/2 gallons of a water-calcium chloride solution. The latter solution functions to provide the system with the desired control crushing characteristics. The hydro-cell portable energy absorbing system, although being portable in nature and relatively easy to install, has been found to suffer from

the major disadvantage that can not simultaneously satisfy the energy absorption and minimum stopping distance, i.e., deceleration requirements for moving vehicles impacting there against at speeds in excess of 30 m.p.h.

Another known form of impact attenuation system is the modular crash cushion system, which is composed of thirty steel drums, i.e., ten rows with three drums per row. The thirty drums rest on a trailer, which is designed to be attached to a highway service vehicle at 5 points to provide the required degree of horizontal and vertical stability during impact. The principal disadvantage of the modular crash cushion portable energy absorbing system stems from the fact that it is 19 1/2 feet long. As a consequence, because of the need to maintain a rigid interconnection between the trailer and the towing service vehicle at all times, this system has been shown to suffer from severe weigh limitations as concerned both the trailer on which the drums rest and the service vehicle which tows the trailer. In addition, because of its relatively long length, this system has proven to be unsuitable for use on the hilly and curvy sections of highways and roads, which are found to exist in many areas of the country.

Still another portable energy absorbing system employs hexagonal shaped cardboard cells filled with polyurethane foam in a flexible frame.

The present inventor developed a variety of systems which can be used in conjunction with either a stationary barrier or on a moving vehicle. These systems are disclosed in U.S. Patent No. 4,200,310 issued to J. Carney, III, on April 29, 1980; in U.S. Patent No. 4,645,375, issued to J. Carney, III, issued on February 24, 1987; and U.S. Patent No. 5,011,326 issued to J. Carney, III, on April 30, 1991. The Carney patents disclose stationary or portable impact attenuation systems which use a series of circular shaped cylinders which are attached together. The cylinders are made of a material which fails at a given and predictable

force to cushion the blow.

Chapter 8 of the Roadside Design Guide published by the American Association of State Highway and Transportation Officials in 1989 discusses nine impact attenuation systems. The sandwich system such as that developed by HI-DRO uses round barrels placed in rows with the entire system wrapped in a belt and some of the rows separated by diaphragms. The cell cluster system as developed by HI-DRO also uses round cells clustered together and surrounded by a belt. The hex-foam sandwich system uses hexagonal shaped cardboard filled with polyurethane foam in a flexible frame. The guardrail energy absorbing terminal also uses hexagonal shaped cardboard filled with polyurethane foam in a flexible frame. Another system is sand-filled plastic barrels which are round and self-explanatory. The Connecticut Impact Attenuation System was developed and patented by the present applicant and uses an array of round barrels. The bullnose attenuator uses a guardrail that wraps around the vehicle during penetration and breaks off a series of posts to slow down the vehicle. The dragnet system is a net which slows the vehicle upon contact. Another system is the gravel-bed attenuator which is a pit of gravel.

While my prior systems have proven to be effective and commercially successful, there is always room for improvement. The prior systems were and are bulky because of the size of the cylinders used in the systems. The cylinders in the prior systems are all cylindrical and round in cross section. By using round cylinders, the prior art systems are wider than I have now found to be necessary to retain the effectiveness of the systems, and more material is used in the construction of the systems, thus causing them to be more costly than is desired.

What is needed, then, is a new and improved energy absorbing system, suitable for dissipating the energy created by the impact of an errant vehicle. The system should be particularly adaptable to provide protection to men and

equipment engaged in highway and road maintenance and/or repair operations. This system must be capable of absorbing most of the energy dissipated in a high speed collision between a moving vehicle and a highway service vehicle. Moreover, the system should be capable of absorbing this energy in such a way that the acceleration and the acceleration rates to which the moving vehicle and the highway service vehicle are subjected as a consequence of a collision between them are within the guidelines specified by the Federal Highway Administration. Also, the use of the system should be unrestricted by the existence of hilly and/or curved sections of highways and roads. Furthermore, the system should be inexpensive to construct and employ. The system should be of a size and shape to minimize its dimensions in those directions which do not add to the effectiveness of the system. The system should be adaptable for use with stationary barriers also, in order to dissipate the energy of a crash by an errant vehicle and thereby protect the driver of the vehicle and his property. This system is presently lacking in the prior art.

DISCLOSURE OF THE INVENTION

The present invention discloses an energy attenuation system which uses vertically standing, hollow, cylindrical energy dissipators having elliptical or oval shaped cross sections. The energy dissipators of my energy attenuation system are hollow cylinders. They are open at both ends (hence the use of the term "cylinders" rather than "barrels"), and have an elliptical cross section. Using cylinders rather than barrels enables me to better control the shape and manner of the crushing of the cylinders under impact loading and thereby control the response of the vehicle to reduce injury and property damage.

While the cross section shape of the cylinders is referred to as being "elliptical", which term denotes a symmetry of cross section shape along both the major axis and

the minor axis, the term in this application is used to denote a cylinder that has a cross section that is oblong in shape, i.e., a shape that has a major axis and a minor axis but which does not have to be symmetrical. Thus, the term "elliptical" as used herein will be considered to include cylinders that have cross sections that are egg shaped, oval, oblong, etc. However, the term does not include cylinders that are round in cross section. The significance of this distinction will be explained in conjunction with the description of the preferred embodiment of the invention.

The cylindrical energy dissipators with elliptical shaped cross sections of the present invention can be used in connection with other energy attenuation systems previously known which relied upon cylinders having round cross sections. However, as the preferred embodiment of my invention, I disclose an energy attenuation system which is simple in its design and construction when compared to the prior art devices and which is relatively inexpensive to construct.

In the application of my system in conjunction with a road service vehicle, I use a bracket which is attached to the truck and a brace which is pivotally attached to the bracket. The brace is then attached to a plate. One or more elliptical cylinders are attached to the plate such that the minor diameters of the elliptical cylinders run substantially parallel to the plate and the major diameters of the elliptical cylinders run substantially perpendicular to the plate. If more than one cylinder is used, the cylinders are joined together. The cylinders have an axis and the cylinders are arranged so that their axis are substantially vertical. Thus, the cylinders will be positioned to have a top and a bottom. A slit is cut out of the cylinders proximate to the top and the bottom. The cylinders are attached to the plate using standard bolts or any other well known attachment method. Similarly, the cylinders are attached to one another using general recognized types of

attachment such as by bolting or welding. The bracket includes a telescoping arm attached to the lower portion of the work piece. When the telescoping arm is extended, the plate rotates about a fixed pivot point near the top of the plate so that the system can be raised off of the ground.

It is therefore an object of the present invention to provide a novel and improved form of energy absorbing system operable as an impact attenuation device to reduce the severity of vehicular collisions.

It is another object of the present invention to provide such an energy absorbing system which is capable of being employed either as a portable energy absorbing system or as a stationary energy absorbing barrier.

A further object of the present invention is to provide such an energy absorbing system which is particularly suited for protection of men and equipment while the latter engage in the performance of highway maintenance and repair operations.

Yet another object of the present invention is to provide such an energy absorbing system which is capable of dissipating the energy produced during a vehicular collision in such a way that the accelerations to which vehicles are subjected during such collisions fall within the prescribed guidelines established by the Federal Highway Administration for such events.

Still another object of the present invention is to provide such an energy absorbing system which is capable of being employed on hilly and curved sections as well as level and straight sections of highways and roads.

Still a further object of the present invention is to provide such an energy absorbing system which is both inexpensive to construct and easy to employ.

Still a further object of the present invention is to provide an energy absorbing system, which is capable of sustaining a greater burden of collision using a shorter length of system.

A still further object of the present invention is to provide a system which is of a reduced size without reducing its effectiveness when compared to prior systems.

A still further object of the present invention is to provide a longer collapse stroke with the same material and/or minor diameter.

A further object of the present invention is to provide a resisting force over a longer stroke.

Fig. 1 is a perspective view of the impact attenuation system of the present invention as attached to a truck as a work piece.

Fig. 2 is a plan view of the impact attenuation system of the present invention as attached to a truck as a work piece.

Fig. 2a is a plan view of the impact attenuation system of the present invention in a simpler form than the structure of Fig. 2.

Fig. 3 is a side view of the impact attenuation system of the present invention as attached to a truck as a work piece in an operating position.

Fig. 4 is a side view of the impact attenuation system of the present invention as attached to a truck as a work piece in a traveling position.

Fig. 5 is a perspective view of a cylinder of the present invention detailing the slits.

Fig. 6 is a side view of a cylinder of the impact attenuation system receiving an automobile in a head-on collision.

Fig. 7 is a plan view of the impact attenuation system of the present invention in its simplest form as attached to a truck as a work piece.

Fig. 7a shows the system of Fig. 7 with bracing to increase the energy dissipation capacity of the system.

Fig. 8 is a side view of the impact attenuation system of the present invention as attached to an off-ramp divider as a stationary work piece.

Fig. 9 is a plan view of the impact attenuation system of Fig. 8.

Fig. 10 is a plan view of the impact attenuation system of my invention wherein the elliptical cylinders are aligned in two parallel rows with the adjacent cylinders being in staggered relationship rather than in a side-by-side relationship.

BEST MODE FOR CARRYING OUT THE INVENTION

Referring now to Figs. 1 and 2 there is shown generally at 10 the impact attenuation system of the present invention. Impact attenuation system has attachment member 14 and elliptical cylinders 16, 18. Figs. 1 and Fig. 2 shows first elliptical cylinders 16 attached to work piece 12 which is a truck. Second elliptical cylinders 18 are attached to first elliptical cylinders 16. Cylinders 16, 18, have major diameter 20, minor diameter 22, top 24, bottom 26, front 28, and back 30. Attachment member 14 generally consists of plate 36 attached to brace 34 which is attached to bracket 32 by pin 33. The cylinders may be braced as shown in Fig. 7a to increase their stiffness and increase their energy dissipation capacities. This bracing could be provided in one, several, or all of the cylinders of a multi-cylinder configuration of the system of my invention.

Referring now to Figs. 3 and 4 there is shown generally at 40 the mechanism for raising the impact attenuation system of the present invention into a stored position when not in use or during the movement of the truck from one work location to another. This is a known system for raising an impact attenuation system into a stored position, and other mounting structures can be used without departing from the spirit of the invention.

Mechanism 40 includes hydraulic cylinder 42 attached to second bracket 44 which attaches to plate 36 by second pin 46 and to workpiece 12 by third bracket 60 and third pin 62. Cylinder 42 has opening 56 to receive hydraulic fluid from

hose 58. As cylinder 42 is filled and extended, plate 36 pivots about pins 33 to raise cylinder 16.

Cylinders 16 are attached to plate 36 by bolts 48 in the preferred embodiment. However, cylinders 16, 18 can be attached to plate 36 in any convenient manner such as by bolts, rivets, or by welding. Cylinders 16, 18 are secured proximate to top 24 and bottom 26 by bolts 48.

As shown in Figs. 5 and 6, at top 24 and bottom 26 of back 30 of rear cylinder 18 there is placed an arcuate slit 50 which runs radially around a portion of the circumference of cylinders 18. This allows proper failure and prevents colliding vehicle 64 from submarining under or vaulting over cylinder 18. If the system is constructed using a single cylinder 16 or a single row of cylinders 16, then cylinders 16 is provided with slit 50 on rear side 30.

Fig. 7 shows the system 10 in its simplest embodiment. Cylinder 16 having front 28 and back 30 is attached to plate 36 by bolts 48 (one each at the top and bottom of cylinder 36). Bracket 32 joins plate 36 to workpiece (not shown) in any convenient manner. Cables 66 can be used to provide lateral stability to cylinder 16. Cables 66 attach proximate to end of minor diameter 22 and to the spaced ends of plate 36. The cables can be attached at the mid-point of the cylinder and the mid-point of the plate 36 or at the top and bottom of each.

Referring now to Figs. 8 and 9 there is shown generally at 10 still another embodiment of the present invention. In this instance, first elliptical cylinder 16 is attached to a work piece 12 either directly, or through an intermediary structure 14 such as plate 36, by bolt 48. In this instance, work piece 12 is an off-ramp divider. As is true throughout, cylinder 16 has major diameter 20 and minor diameter 22. Major diameter runs axially along the direction of median divider 12. In this instance, second elliptical cylinder 18 attaches to first elliptical cylinder 16 by bolts 48. As can be seen from Figs. 8 and 9, first elliptical cylinder 16 is

attached to second elliptical cylinder **18** such that the major diameters **20** are in substantial alignment with the minor diameter **22** being substantially parallel. Cables **66** attach to divider **12** at one end and to ground **68** at the other end. In between the two ends, cables **66** attaches to cylinders **16**, **18**, proximate to the ends of their minor diameters **22** at or near the mid-point of their heights. Cables **66** help to hold the cylinders in position during impact and slits **50** are provided in rear cylinder **18** proximate to back **30** to prevent submarining and vaulting. Cables **66** prevent cylinders **16**, **18** from rotating and exposing divider **12**.

Fig.7 shows single cylinder **16** attached to work piece. Figs. 1-4 show plural cylinders **16**, **18** attached in parallel. Figs. 8 and 9 show plural cylinders **16**, **18** in series. However, the embodiments can be provided with any number of cylinders **16**, **18** in series as well as in parallel at the same time. Therefore, 3, 4, 5, or more cylinders can be attached together to reach the desired results.

Referring now to Figure 10, an alternate arrangement of the elliptical cylinders of my system can be seen. In this arrangement, the two parallel rows of cylinders have the cylinders in adjacent rows in staggered relationship rather than in a side-by-side arrangement. This arrangement of the cylinders gives greater resistance to crushing upon impact and therefore allows the use of fewer cylinders. Also, this system is not as wide as the system using the cylinders in a side-by-side arrangement.

In the preferred embodiment, when system **10** is mounted onto truck **12** as shown in Figs. 1-4, clearance between bottom **26** and ground **54** is nominal (generally in the range of six inches) in order for the cylinder **18** to "catch" an errant vehicle in the manner illustrated in Fig. 6. When truck **12** is traveling from one work site to another, system **10** is raised higher so that it does not bump on the ground and wear on the bottom **26** of system **10**.

Presently, under Federal Highway Administration

guidelines, an impact attenuation system must perform satisfactorily under the impact between a stationary barrier and a forty-five hundred pound vehicle travelling forty-five miles per hour. However, in the near future, the standards will require that a forty-five hundred pound vehicle be brought to a controlled stop under a sixty miles per hour impact. The limiting factor of the above equation is that the acceleration must be kept within certain limits because the human body can only withstand certain acceleration or, in this case, deceleration. I have found that to produce a controlled stop of a forty-five hundred pound vehicle going forty-five miles per hour, a system as shown in Fig. 2a with the cylinders having a major diameter of eight feet and a minor diameter of four feet will be sufficient to meet the criteria. Besides being larger and more cumbersome, a similar system using round cylinders having a diameter of eight feet will not accomplish the same satisfactory results.

Figs. 1-10 show specific embodiments of the present impact attenuation system. However, the oval-shaped or elliptical cylinders of the present invention can be used in place of round cylinders in any known impact attenuation system. Accordingly, the impact attenuation systems disclosed in U.S. Patent No. 4,200,310, issued to J. Carney, III, on April 29, 1990; U.S. Patent No. 4, 645,375, issued to J. Carney, III, on February 24, 1987; and U.S. Patent No. 5,011,326, issued to J. Carney, III, on April 30, 1991 are incorporated herein by reference with the circular cylinders being replaced with the oval-shaped or elliptical cylinders.

Thus, although there have been described particular embodiments of the present invention of a new and useful "Impact Attenuation Device", it is not intended that such references be construed as limitations upon the scope of this invention except as set forth in the following claims. Further, although there have been described certain dimensions used in the preferred embodiment, it is not intended that such dimensions be construed as limitations

upon the scope of this invention except as set forth in the following claims.

## CLAIMS

What I claim is:

1. An attenuation system mountable to a workpiece wherein the workpiece is proximately located to an automobile traffic passageway and has a longitudinal direction which is parallel to the direction of flow of traffic along the passageway comprising:

a. means for attaching said attenuation system to said workpiece; and

b. a first cylinder, said first cylinder having an elliptical cross section with a major diameter and a minor diameter, a top and a bottom, a front and a back distally located from said front along said major diameter, said first cylinder attached at its front to said means for attaching said attenuation system to said workpiece so that the major diameter is parallel to the longitudinal direction of the workpiece.

2. The system of Claim 1 wherein said first cylinder attaches to said means for attaching said attenuation system to said workpiece proximate to said top and to said bottom.

3. The system of Claim 1 wherein said means for attaching said attenuation system to said workpiece comprises:

a. a bracket attached to said workpiece;

b. a plate attached to said cylinder; and

c. a brace joining said bracket to said plate.

4. The system of Claim 1 wherein said means for attaching said attenuation system to said workpiece is pivotally attached to said workpiece.

5. The system of Claim 1 wherein said first cylinder has a first radial slit proximate to said top.

6. The system of Claim 5 wherein said first cylinder has a second radial slit proximate to bottom.

7. The system of Claim 1 further comprising means for raising said system.

8. An attenuation system mountable to a workpiece comprising:

a. means for attaching said attenuation system to said workpiece; and

b. a first elliptical-shaped cylinder and a second elliptical-shaped cylinder, said elliptical-shaped cylinders each having a major diameter, a minor diameter, an top and a bottom, a front and a back distally located from said front along said major diameter, said elliptical-shaped cylinders attached to said means for attaching said attenuation system to said workpiece proximate to said fronts, said major diameters of said elliptical-shaped cylinders aligned in substantial parallel alignment, said elliptical-shaped cylinders attached to one another proximate to said minor diameters.

9. The system of Claim 8 wherein said elliptical-shaped cylinders attach to said means for attaching said attenuation system to said workpiece at two points, one proximate to said top and the other proximate to said bottom.

10. The system of Claim 8 wherein said means for attaching said attenuation system to said workpiece comprises:

a. a bracket attached to said workpiece;

b. a plate attached to said elliptical-shaped cylinders; and

c. a brace joining said bracket to said plate.

11. The system of Claim 8 wherein said means for attaching said attenuation system to said workpiece is pivotally attached to said workpiece.

12. The system of Claim 8 wherein said elliptical-shaped cylinders each have a first radial slit proximate to said top and a second radial slit proximate to said bottom.

13. The system of Claim 8 further comprising means for raising said system.

14. The system of Claim 13 wherein said means for raising said system comprises a hydraulic cylinder attaching said workpiece and said means for attaching said attenuation system to said workpiece.

15. The system of Claim 8 wherein said workpiece is a truck.

16. An impact attenuation system for dissipating the energy generated when an errant moving vehicle collides with a protected structure, the system being located in close proximity to a highway over which vehicles travel in a predetermined direction, the system comprising:

a. means for connecting the system to the protected structure; and

b. at least one hollow cylinder having an axis, the axis being substantially vertically aligned, the cylinder having an open top and an open bottom, the cylinder having an elliptical cross section along any plane perpendicular to its axis, said cross section of the cylinder having a major diameter and a minor diameter at any point along its axis in a plane perpendicular to its axis, the cylinder connected to the protected structure at its perimeter at a point located at substantially the maximum radial distance of the perimeter from the axis of the cylinder and the minor axis of the cylinder being substantially perpendicular to the predetermined direction of travel of vehicles along said highway.

17. The system as described in claim 16 wherein the cylinder is connected to the protected structure at two points, one adjacent to the top of the cylinder and the other at or adjacent to the bottom of the cylinder.

18. The system as described in claim 16 further comprising two cylinders of elliptical cross section arranged in side by side relationship, each connected to the protected structure and connected to each other at or near the top and

at or near the bottom of the cylinders.

19. The system as described in claim 16 further comprising two or more cylinders having elliptical cross sections and aligned in such a way that the major diameters of the elliptical cross sections of the cylinders are parallel to each other and the cylinders are connected to the protected structure at their periphery at the point that is the maximum radial distance of the major diameter from the axis of each cylinder.

20. The system as described in claim 16 further comprising four or more cylinders of similar shape wherein the cylinders are aligned in two rows, the major diameter of each cylinder being parallel to the major diameter of every other cylinder and the minor diameters of each cylinder being parallel to the minor diameter of every other cylinder.

21. The system as described in claim 20 wherein the two rows of cylinders are in parallel side by side relationship and are connected to each other at the points where they touch.

22. The system as described in claim 21 wherein the connection of the cylinders in side by side relationship is at a point at or approximate to the top of the cylinders and a second connection at or approximate to the bottom of the cylinders.

23. The system as described in claim 16 wherein cables also connect the cylinder to the protected structure and to the ground.

24. The system as described in claim 16 further comprising four or more cylinders of similar shape and wherein the major diameter of the cylinders are parallel and there are two rows of cylinders with the cylinders of each row having their major diameters in a series relationship.

25. The system as described in claim 24 wherein the cylinders in the adjacent rows are in side by side relationship.

26. The system as described in claim 24 wherein the

cylinders in adjacent rows are in staggered relationship.

27. The system as described in claim 20 wherein the cylinders furthest from the protected structure have at their peripherial area furthest from the protected structure a slit cut in the top and the bottom thereof, said slits being substantially perpendicular to the axis of the cylinders.

28. The system as described in claim 26 wherein the cylinders touch and create a line of contact between them, and said cylinders are connected at one point approximate to the top thereof and at another point approximately to the bottom thereof along each line of juncture where the cylinders touch.

29. The system as described in claim 16 wherein the cylinders have a major diameter of approximately 8 ft. and a minor diameter of approximately 4 ft.

30. The system as described in claim 16 wherein the peripherial area of the cylinder furthest from the protected structure has slits cut in the top and the bottom thereof, said slits being substantially perpendicular to the axis of the cylinder.

31. The system as described in claim 16 further comprising two or more cylinders having elliptical cross sections and aligned in such a way that the major diameters of the elliptical cross sections of the cylinders are parallel to each other and the cylinders are connected to each other at their periphery at the point that is the maximum radial distance of the major diameter from the axis of each cylinder.

32. The system as described in claim 16 wherein the cylinders are aligned so that their major diameters are in series relationship and one of the cylinders is attached to the protected structure.

33. The system as described in claim 32 wherein the cylinder furthest from the protected structure has at its peripherial area furthest from the protected structure a slit cut in the top and the bottom thereof, said slits being

substantially perpendicular to the axis of the cylinders.

AMENDED CLAIMS

[received by the International Bureau on 4 March 1994 (04.03.94) ; original claims 1-33 replaced by amended claims 1-33(7 pages)]

1. An attenuation system mountable to a workpiece wherein the workpiece is proximately located to an automobile traffic passageway and has a longitudinal direction which is parallel to the direction of flow of traffic along the passageway comprising:

a. means for attaching said attenuation system to said workpiece; and

b. a first cylinder, said first cylinder having an elliptical cross section with a major diameter and a minor diameter, said major diameter and said minor diameter both being substantially parallel to said automobile traffic passageway, a top and a bottom, a front and a back distally located from said front along said major diameter, said first cylinder attached at its front to said means for attaching said attenuation system to said workpiece so that the major diameter is parallel to the longitudinal direction of the workpiece.

2. An attenuation system mountable to a workpiece wherein the workpiece is proximately located to an automobile traffic passageway and has a longitudinal direction which is parallel to the direction of flow of traffic along the passageway comprising:

a. means for attaching said attenuation system to said workpiece;

b. a first cylinder, said first cylinder having an elliptical cross section with a major diameter and a minor diameter, a top and a bottom, a front and a back distally located from said front along said major diameter, said first cylinder attached at its front to said means for attaching said attenuation system to said workpiece so that the major diameter is parallel to the longitudinal direction of the workpiece; and

c. said means for attaching said attenuation system to said workpiece is attached to said first cylinder at one point proximate to said top and at another point proximate to said bottom.

3. The system of Claim 1 wherein said means for attaching said attenuation system to said workpiece comprises:

a. a bracket attached to said workpiece;

b. a plate attached to said cylinder; and

c. a brace joining said bracket to said plate.

4. The system of Claim 1 wherein said means for attaching said attenuation system to said workpiece is pivotally attached to said workpiece.

5. An attenuation system mountable to a workpiece wherein the workpiece is proximately located to an automobile traffic passageway and has a longitudinal direction which is parallel to the direction of flow of traffic along the passageway comprising:

a. means for attaching said attenuation system to said workpiece;

b. a first cylinder, said first cylinder having an elliptical cross section with a major diameter and a minor diameter, a top and a bottom, a front and a back distally located from said front along said major diameter, said first cylinder attached at its front to said means for attaching said attenuation system to said workpiece so that the major diameter is parallel to the longitudinal direction of the workpiece; and

c. a first radial slit proximate to said top of first said cylinder.

6. The system of Claim 5 wherein said first cylinder has a second radial slit proximate to said bottom.

7. The system of Claim 1 further comprising means for raising said system.

8. An attenuation system mountable to a workpiece comprising:

a. means for attaching said attenuation system to said workpiece; and

b. a first elliptical-shaped cylinder and a second elliptical-shaped cylinder, said elliptical-shaped cylinders each having a major diameter, a minor diameter, a top and a bottom, a front and a back distally located from said front along said major diameter, said elliptical-shaped cylinders attached to said means for attaching said attenuation system to said workpiece proximate to said fronts, said major diameters of said elliptical-shaped cylinders aligned in substantial parallel alignment, said elliptical-shaped cylinders attached to one another proximate to said minor diameters.

9. The system of Claim 8 wherein said elliptical-shaped cylinders attach to said means for attaching said attenuation system to said workpiece at two points, one proximate to said top and the other proximate to said bottom.

10. The system of Claim 8 wherein said means for attaching said attenuation system to said workpiece comprises:

a. a bracket attached to said workpiece;

b. a plate attached to said elliptical-shaped cylinders; and

c. a brace joining said bracket to said plate.

11. The system of Claim 8 wherein said means for attaching said attenuation system to said workpiece is pivotally attached to said workpiece.

12. The system of Claim 8 wherein said elliptical-shaped cylinders each have a first radial slit proximate to said top and a second radial slit proximate to said bottom.

13. The system of Claim 8 further comprising means for raising said system.

14. The system of Claim 13 wherein said means for raising said system comprises a hydraulic cylinder attaching said workpiece and said means for attaching said attenuation system to said workpiece.

15. The system of Claim 8 wherein said workpiece is a truck.

16. An impact attenuation system for dissipating the energy generated when an errant moving vehicle collides with a protected structure, the system being located in close proximity to a highway over which vehicles travel in a predetermined direction, the system comprising:

a. means for connecting the system to the protected structure; and

b. at least one hollow cylinder having an axis, the axis being substantially vertically aligned, the cylinder having an open top and an open bottom, the cylinder having an elliptical cross section along any plane perpendicular to its axis, said cross section of the cylinder having a major diameter and a minor diameter at any point along its axis in a plane perpendicular to its axis, the cylinder connected to the protected structure at its perimeter at a point located at substantially the maximum radial distance of the perimeter from the axis of the cylinder and the minor axis of the cylinder being substantially perpendicular to the predetermined direction of travel of vehicles along said highway.

17. The system as described in claim 16 wherein the cylinder is connected to the protected structure at two points, one adjacent to the top of the cylinder and the other at or adjacent to the bottom of the cylinder.

18. The system as described in claim 16 further comprising two cylinders of elliptical cross section arranged in side by side relationship, each connected to the protected structure and connected to each other at or near the top and

at or near the bottom of the cylinders.

19. The system as described in claim 16 further comprising two or more cylinders having elliptical cross sections and aligned in such a way that the major diameters of the elliptical cross sections of the cylinders are parallel to each other and the cylinders are connected to the protected structure at their periphery at the point that is the maximum radial distance of the major diameter from the axis of each cylinder.

20. The system as described in claim 16 further comprising four or more cylinders of similar shape wherein the cylinders are aligned in two rows, the major diameter of each cylinder being parallel to the major diameter of every other cylinder and the minor diameters of each cylinder being parallel to the minor diameter of every other cylinder.

21. The system as described in claim 20 wherein the two rows of cylinders are in parallel side by side relationship and are connected to each other at the points where they touch.

22. The system as described in claim 21 wherein the connection of the cylinders in side by side relationship is at a point at or approximate to the top of the cylinders and a second connection at or approximate to the bottom of the cylinders.

23. The system as described in claim 16 wherein cables also connect the cylinder to the protected structure and to the ground.

24. The system as described in claim 16 further comprising four or more cylinders of similar shape and wherein the major diameter of the cylinders are parallel and there are two rows of cylinders with the cylinders of each row having their major diameters in a series relationship.

25. The system as described in claim 24 wherein the cylinders in the adjacent rows are in side by side relationship.

26. The system as described in claim 24 wherein the

cylinders in adjacent rows are in staggered relationship.

27. The system as described in claim 20 wherein the cylinders furthest from the protected structure have at their peripherial area furthest from the protected structure a slit cut in the top and the bottom thereof, said slits being substantially perpendicular to the axis of the cylinders.

28. The system as described in claim 26 wherein the cylinders touch and create a line of contact between them, and said cylinders are connected at one point approximate to the top thereof and at another point approximately to the bottom thereof along each line of juncture where the cylinders touch.

29. The system as described in claim 16 wherein the cylinders have a major diameter of approximately 8 ft. and a minor diameter of approximately 4 ft.

30. The system as described in claim 16 wherein the peripherial area of the cylinder furthest from the protected structure has slits cut in the top and the bottom thereof, said slits being substantially perpendicular to the axis of the cylinder.

31. The system as described in claim 16 further comprising two or more cylinders having elliptical cross sections and aligned in such a way that the major diameters of the elliptical cross sections of the cylinders are parallel to each other and the cylinders are connected to each other at their periphery at the point that is the maximum radial distance of the major diameter from the axis of each cylinder.

32. The system as described in claim 16 wherein the cylinders are aligned so that their major diameters are in series relationship and one of the cylinders is attached to the protected structure.

33. The system as described in claim 32 wherein the cylinder furthest from the protected structure has at its peripherial area furthest from the protected structure a slit cut in the top and the bottom thereof, said slits being

substantially perpendicular to the axis of the cylinders.

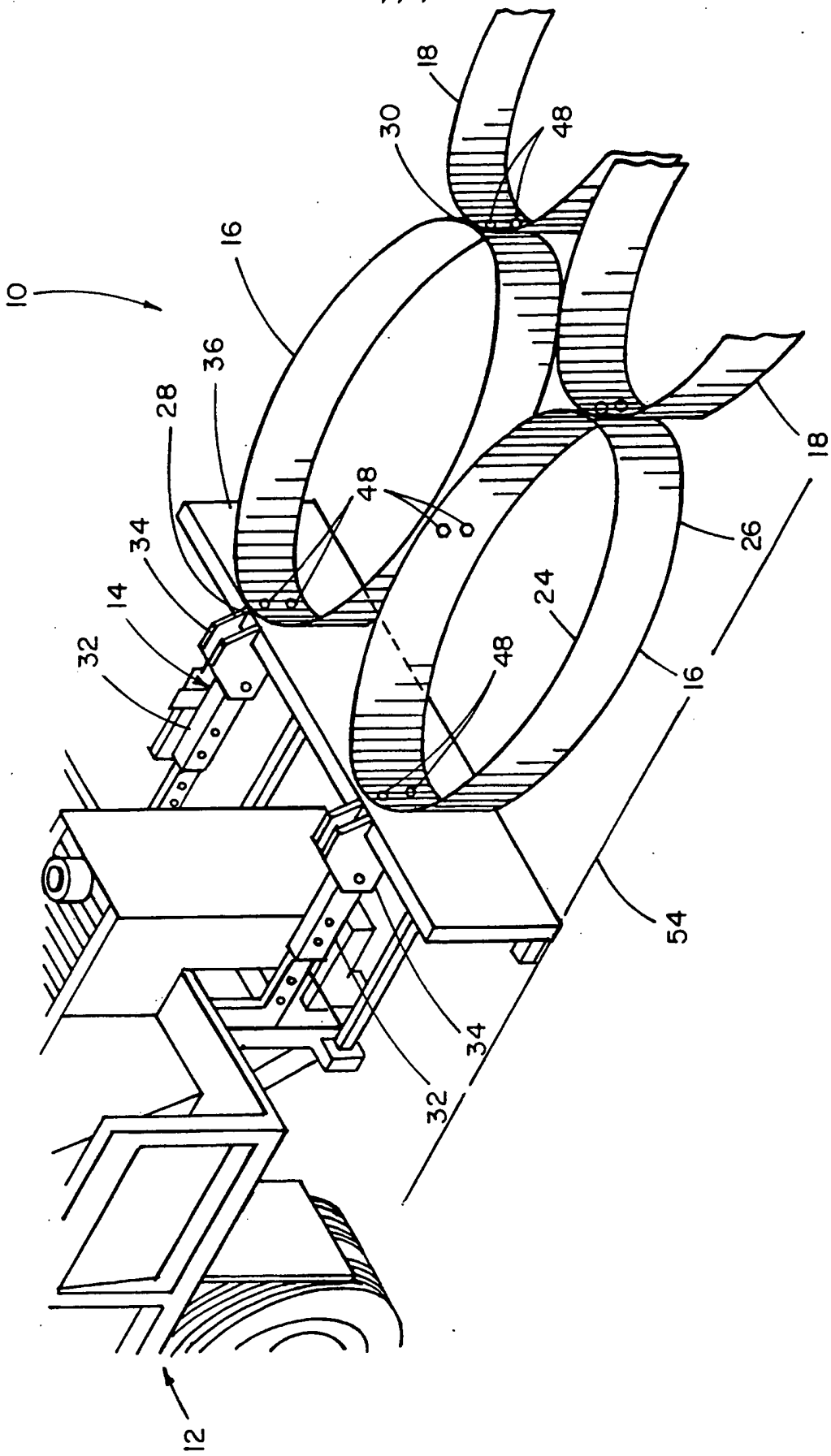


FIG. 1

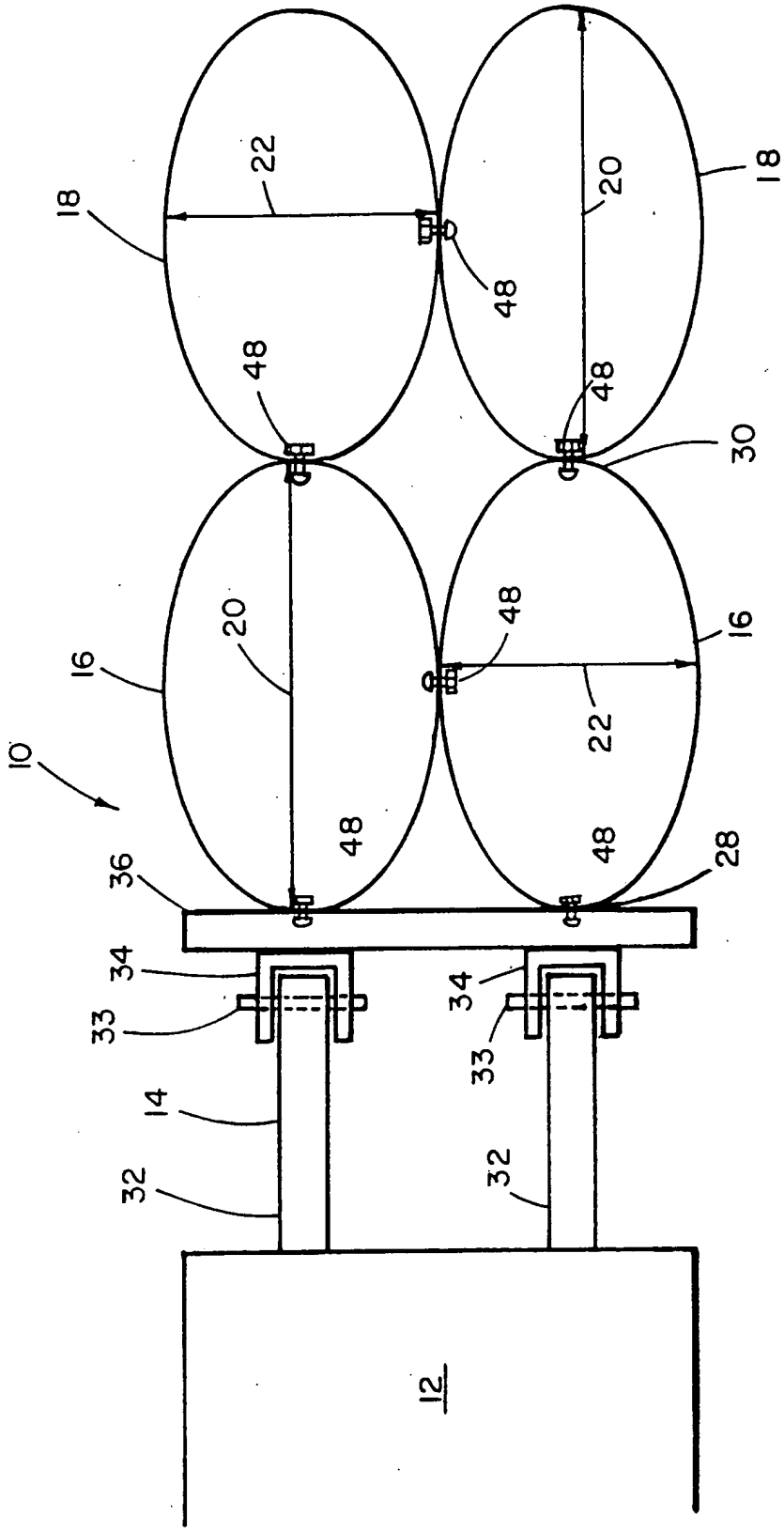
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FIG. 2

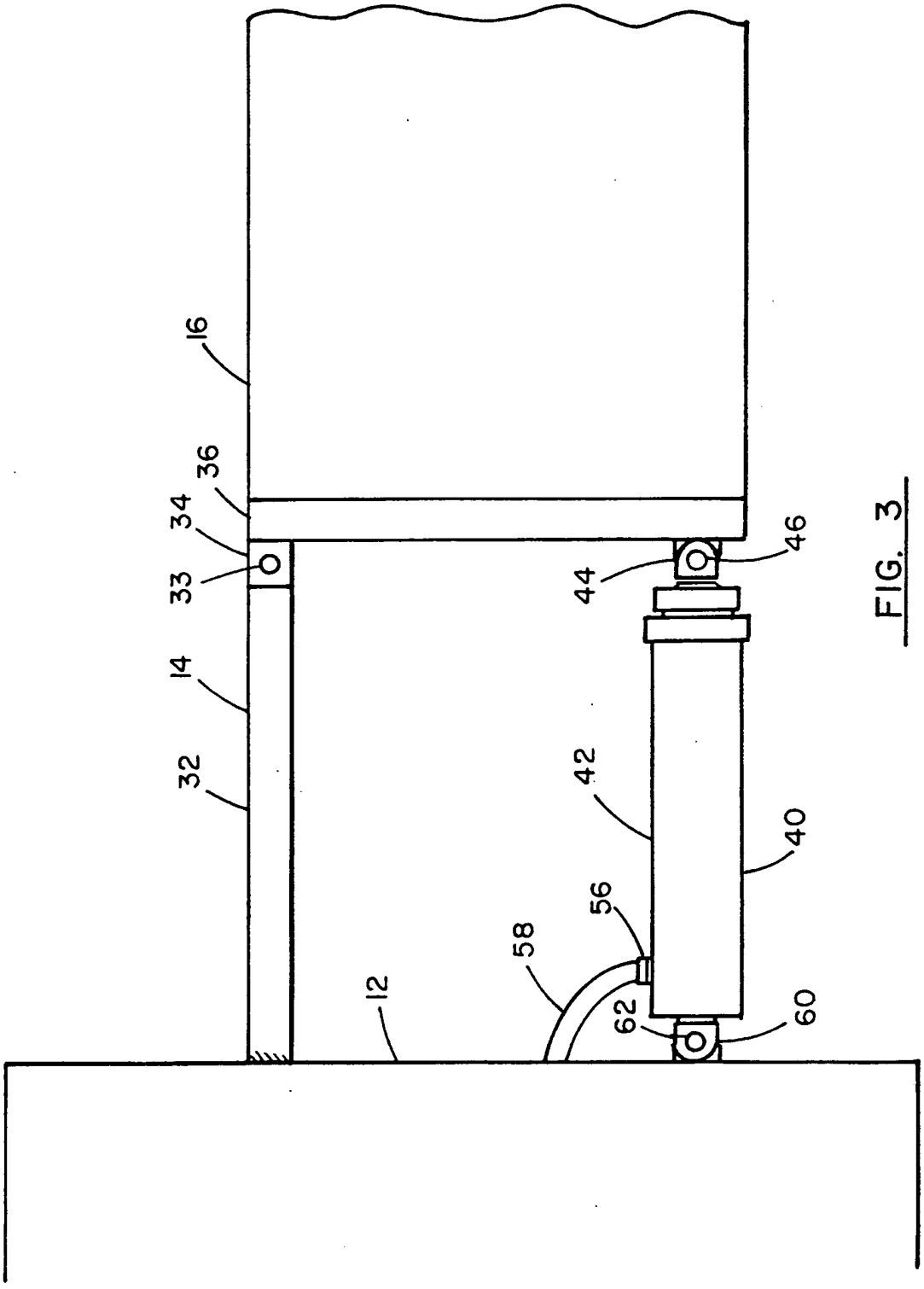


FIG. 3

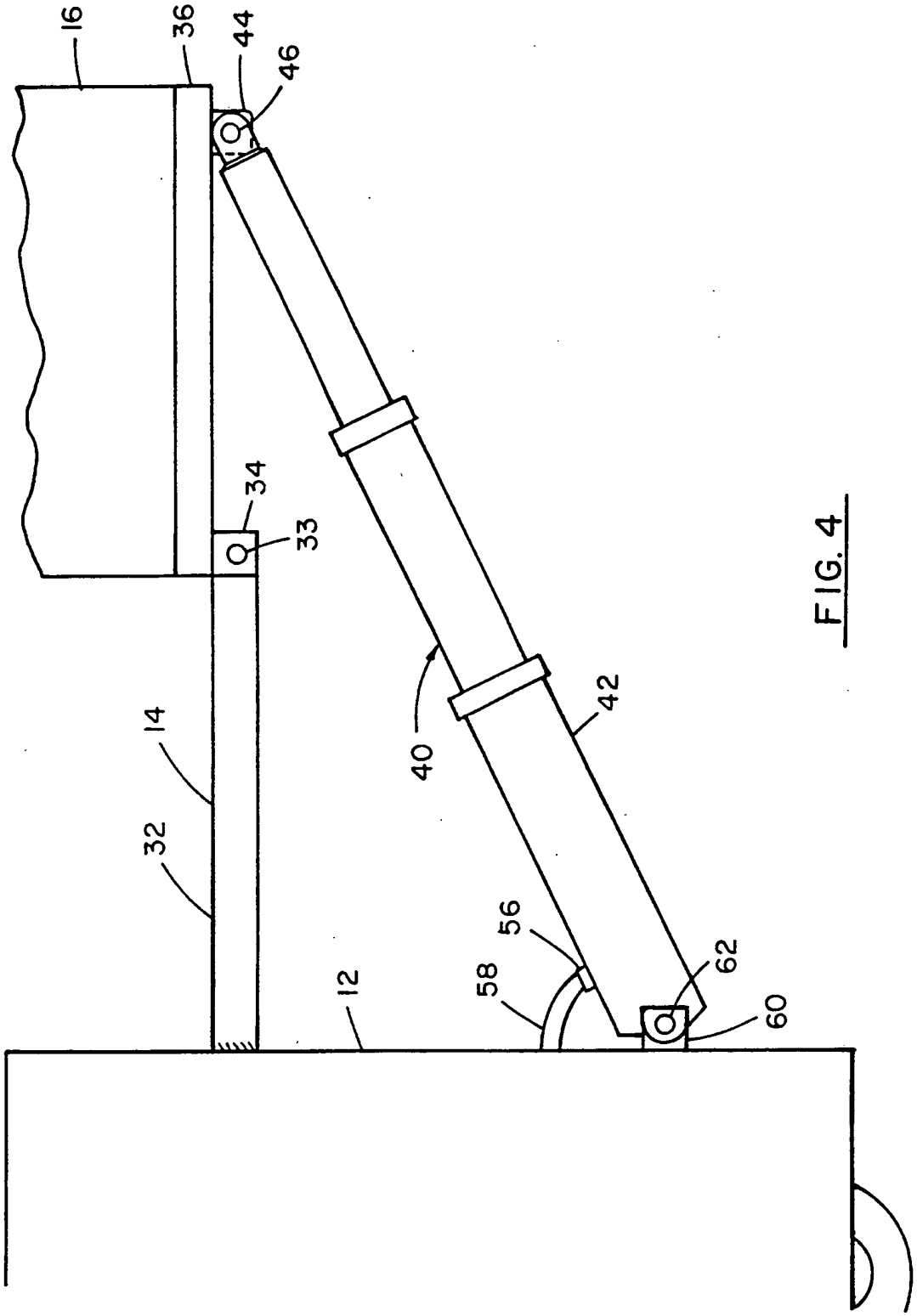


FIG. 4

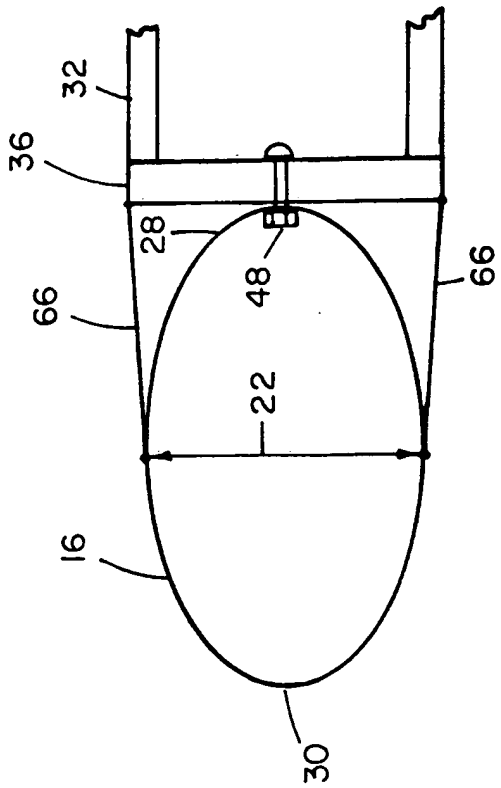


FIG. 7

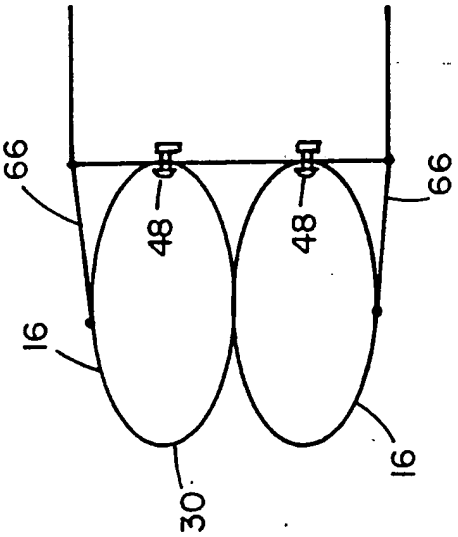


FIG. 2a

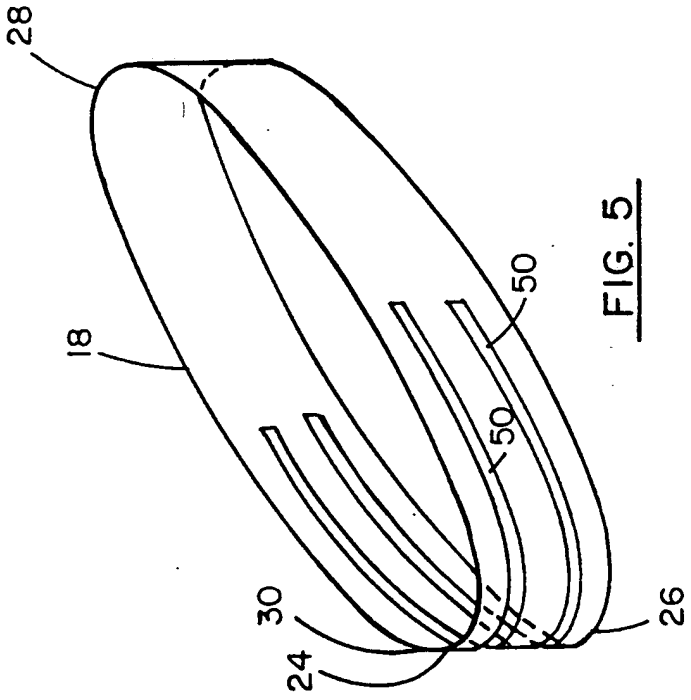


FIG. 5

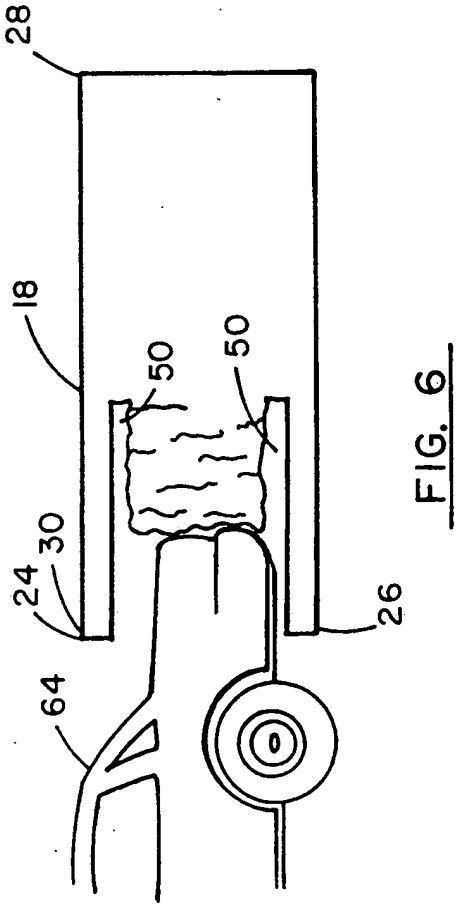


FIG. 6

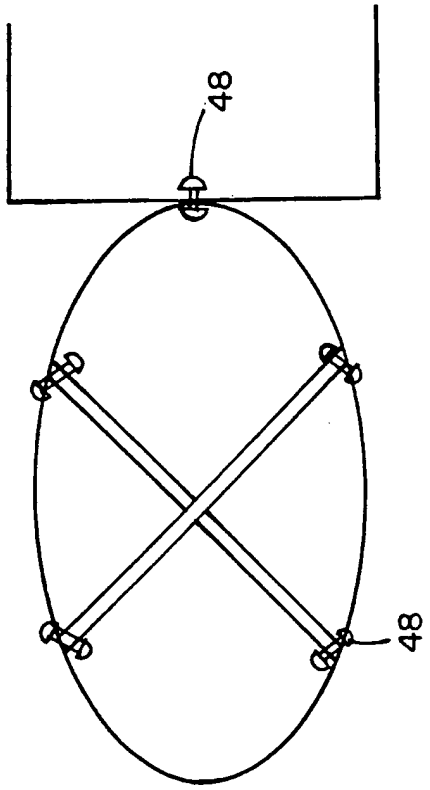


FIG. 7a

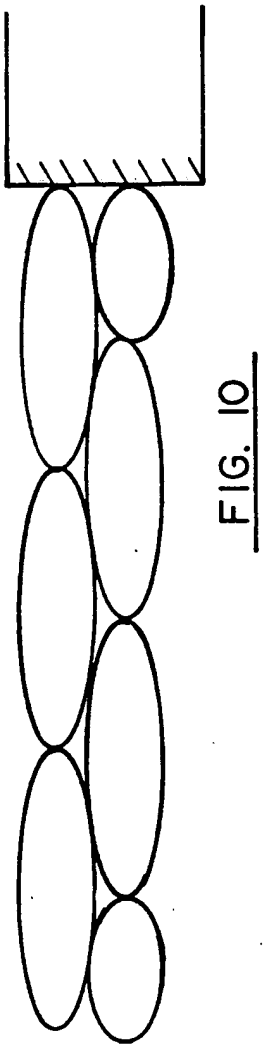

FIG. 10

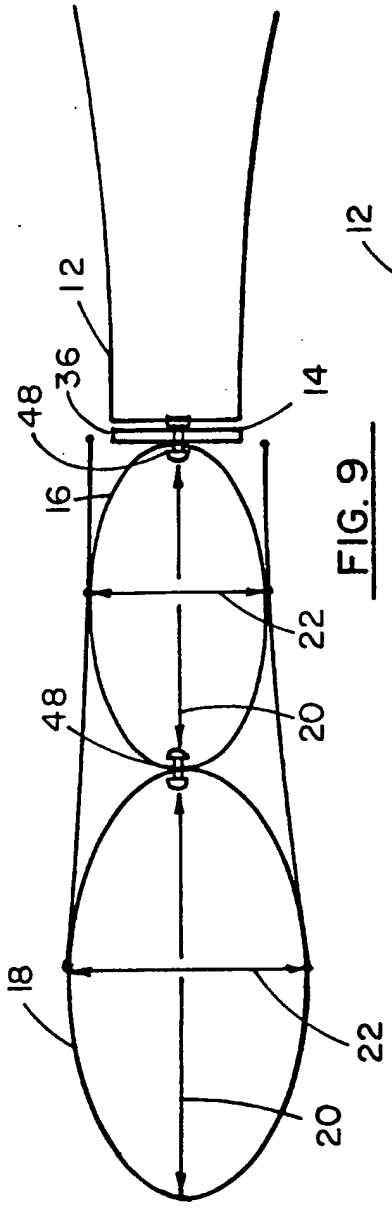


FIG. 9

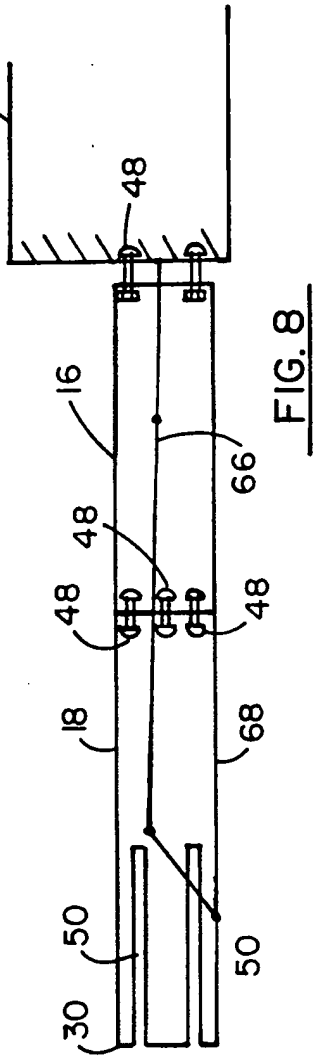


FIG. 8

# INTERNATIONAL SEARCH REPORT

In.. ..national application No.
PCT/US93/08314

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(5) :B60R 19/34,04,26; E01F 13/00,15/00
US CL : 404/6;256/13.1;293/122
According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 404/6,9,10;256/13.1;293/122;280/784;
293/120,123,131,132,133,136

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US,A 5,031,947 (CHEN) 16 JULY 1991 (See entire document) | 1-33 |
| Y | US,A 4,658,941 (GOTTWALD ET AL) 21 APRIL 1987 (See entire document) | 1,4,7,11,13-14 |
| Y | US,A 3,845,936 (BOEDECKER, JR. ET AL) 05 NOVEMBER 1974 (See Figures 12,14) | 26 |
| Y | US,A 4,200,310 (CARNEY, III) 29 APRIL 1980 (See entire document) | 1-7,10,11, 13-15 |
| A | US,A 3,130,998 (ANDERSON) 28 APRIL 1964 (See entire document) | 1-33 |
| Y | US,A 4,645,375 (CARNEY, III) 24 FEBRUARY 1987 (See entire document) | 8-33 |

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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| * | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
| "A" | document defining the general state of the art which is not considered to be part of particular relevance | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "E" | earlier document published on or after the international filing date | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "&" | document member of the same patent family |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | | |

| | |
|---|---|
| Date of the actual completion of the international search<br>05 November 1993 | Date of mailing of the international search report<br>NOV 24 1993 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. NOT APPLICABLE | Authorized officer<br>RAMON BRITTS<br>Telephone No. (703) 308-2168 |

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

Int. ational application No.
PCT/US93/08314

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US,A 4,711,481 (KRAGE ET AL) 08 DECEMBER 1987 (See entire document) | 1-33 |
| A | US,A 5,011,326 (CARNEY, III) 30 APRIL 1991 (See entire document) | 1-33 |
| X<br>--<br>Y | US,A 5,125,762 (STRASSIL) 30 JUNE 1992 (Col. 2, line 8) | 1<br>--<br>1-33 |